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EFFECT OF HERBICIDES (HOEGRASS AND BUCTRIL) ON SOIL INVERTEBRATES IN SOUTH AUSTRALIAN CEREAL CROP LANDS

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ABSTRACT

Field trials on two sandy loam sites were used to examine the influence of two commonly used herbicides, Hoegrass and Buctril.

In the 0-4 cm soil layer of direct drilled wheat plots at Avon, the population density of mites (dominated by Astigmata) fell from 47000 to 12000 m^{-2} after herbicide application. In conventionally cultivated plots the drop was from 35000 to 4500 m^{-2}. The population of Collembola (dominated by Poduridae and Entomobryidae) fell from 25000 to 8000 m^{-2} and 8000 to 5000 m^{-2} in direct drilled and conventionally cultivated plots respectively. Similar reductions in populations also occurred in the 4-8 cm soil layer.

In pasture plots at the Waite Institute the population of mites (dominated by Prostigmata) dropped from 39000 to 13500 m^{-2} soon after a herbicide application and down to 9000 m^{-2} 3 weeks after application of the herbicides.

INTRODUCTION

Methods of preparing seedbeds for cropping without using implements are being practised on a considerable scale. An essential part of the process has been to use herbicides to suppress or eliminate the growth of weeds before direct drilling.

Although there have been some substantial studies of the effect of herbicides on microflora (Grossbard 1976), little work has yet been done to determine the effect of herbicides on soil fauna. Reviews of work undertaken to date on herbicide activity and its effect on soil microflora and fauna can be found in Hance (1980).

The present paper describes the influence at two sites of two commonly used herbicides (Hoegrass and Buctril) on population densities of soil mesofauna using mites and Collembola as examples. In plots sown to wheat at one site (Avon) the effects on the soil fauna of herbicide application on differently treated soils were examined while at the other site (Waite Institute) herbicide effects on plots with pasture were examined without the interaction of different tillage treatments.

SITES AND TREATMENTS

Avon Site

This study area is located on latitude 34°17'S and longitude 138°20'E. Topographically this site consists of a dune-swale topography with a NW-SE trending longitudinal dune forming a north boundary (CSIRO Aust. Div. Soils Tech. Mem. 1/1977). The main soil of this experimental area (fine sandy loam) is formed largely in sandy calcareous strata which is underlain by clay.

A standard mixture of Hoegrass (1 ℓha^{-1}) and Buctril (1.4 ℓha^{-1}) was applied on 18/7/80 to direct drilled (DD) and conventionally cultivated (CC) plots which had been sown to wheat and had been under natural pasture the previous year (1979).

Waite Institute Site

This site is located on latitude 35°57'S and longitude 138°38'E, 100 m above sea level and has a gradual (5%) slope to the west. The Red brown earth soil is Urrbrae fine sandy loam (Chittleborough and Oades 1979). A mixture of herbicides (as at Avon) was applied to half the site (treated plots) on 30/9/80.

SAMPLING MATERIAL AND METHODS

Soil was sampled using cylindrical cores 5 cm in diameter and 4 cm deep. The animals were extracted in Tullgren funnels over 7 days, then counted and identified (mites to suborders, Collembola to families).

Avon Site

Soil was sampled for examination of soil animals before herbicide application on 18/6/80 and four hours after the application on 18/7/80. Thereafter, sampling was at monthly intervals for 13 months. The experiment involved three replicates each of DD and CC plots 300 m^2 in area. Ten cores were taken from each plot at each sampling time (5 cores from the 0-4 cm and 5 cores from 4-8 cm soil layers).

Waite Institute Site

An overall sampling of the 500 m^2 field was carried out before the trial plots were delimited (27/9/80). Twenty-four soil samples (0-4 cm) were taken to determine the population of animals present. The treated and control (untreated) plots were sampled on 3/10/80, 24/10/80 and finally on 5/12/80. Twenty-four cores were taken at each sampling time for each treatment.

STATISTICAL ANALYSIS OF DATA

The design of the Avon experiment was a complete randomised block design. Distribution of animal populations was found to follow the Poisson series where the variance was equal to the mean ($\sigma^2 = \mu$). Hence $\sqrt{x} + \frac{1}{2}$ transformation was found to be the most suitable method for stabilizing the variance before analysis.

The site at the Waite Institute differed from the Avon site thus a different design for data analysis was used. The numbers of animals were low and the variability small and therefore a T-test analysis was used.

RESULTS

Effect of Treatments on Invertebrate Populations at the Avon Site

DD plots contained more soil animals than CC plots both before and after herbicide application. This may have been due to the good, undisturbed micro-habitat in DD plots as compared with the destroyed or changed habitat following CC.

In samples taken four hours after herbicide application at the DD plots, numbers of total mites and the dominant astigmatid order in the 0-4 cm layer were both significantly reduced ($P < 0.001$) by 74 and 83% respectively, and in the CC plots numbers were also significantly reduced ($P < 0.05$) by 88 and 94% respectively (Figs. 1a and 2). A similar trend, i.e. reduction of animals after herbicide treatment, was observed in the 4-8 cm layer of soil. This reduction in numbers in both layers could be ascribed to toxicity of the two herbicides used.

Numbers of Collembola were significantly reduced ($P < 0.05$) by 68% in the DD plots (Fig. 1b), but the reduction of 38% in CC plots was not significant. In the 4-8 cm layer of soil the reductions were 84% in DD plots and 89% in CC plots.

The dominant family of Collembola was the Poduridae with population densities of $35000 m^{-2}$ and $13700 m^{-2}$ in the 0-4cm layers of the DD and CC plots respectively (Fig. 2). Following herbicide application, numbers of Poduridae were reduced by 97% in DD and 80% in CC plots (Fig. 2). In the 4-8 cm layer a similar reduction was recorded.

Effect of Treatments on Invertebrate Populations at the Waite Institute Site

As a result of herbicide treatments soil was left almost bare compared with substantial growth of pasture on the surface of control plots.

Close agreement (Fig. 3) between numbers of animals in the 0-4 cm layer of the trial field before, and the control plots, after herbicide application, and the later significant differences ($P < 0.01$) between mite numbers in the herbicide treated and control plots suggest a direct and immediate effect on soil animals.

The mean densities for all animals in the plots before and after herbicide application and in the control plots are given in Table 1. Significantly more mites were recorded than Collembola ($P < 0.001$). The prostigmatid mites dominated followed by the mesostigmatid mites. After herbicide application populations decreased by 63% and 91% respectively.

Populations of Collembola were generally low with the Poduridae dominant and with some surface dwelling Isotomidae present. There was some reduction in numbers of Collembola after herbicide application but it was not significant.

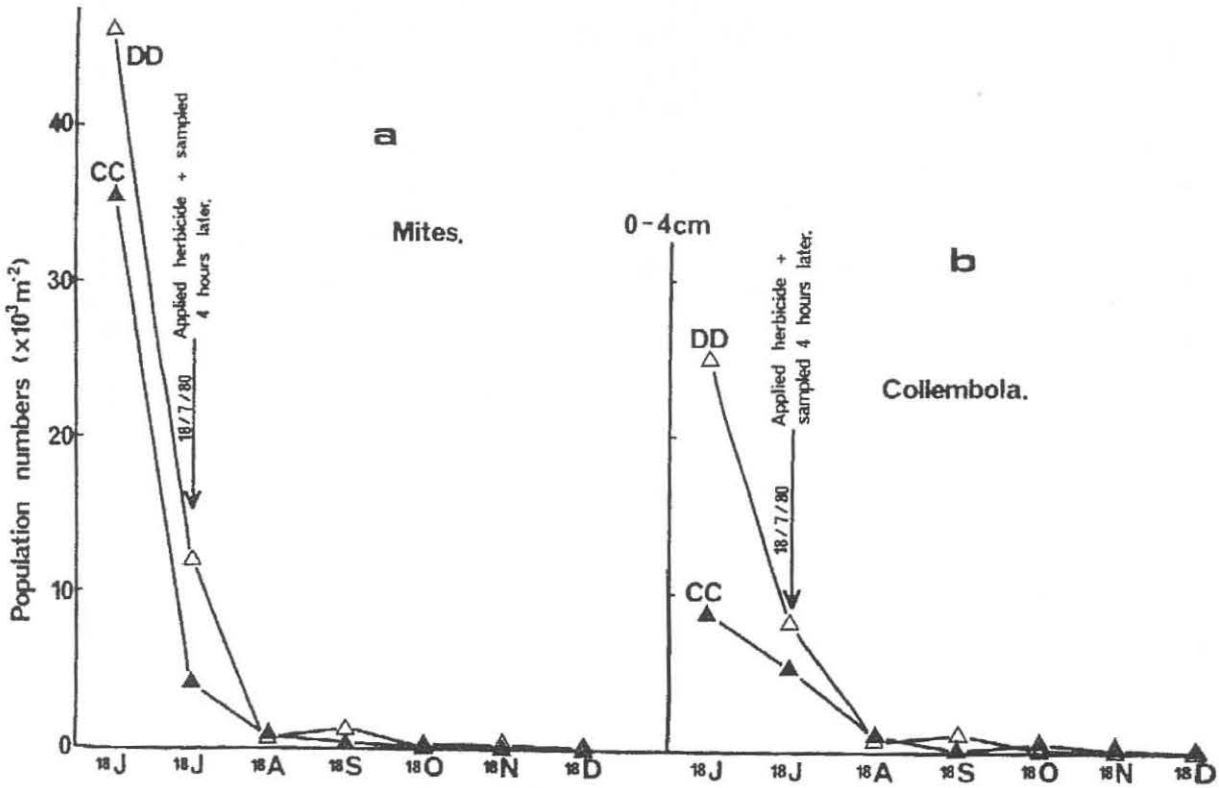

FIGURE 1. Effect of Two Different Seedbed Preparation Treatments and Herbicides on Soil Fauna at the Avon Site

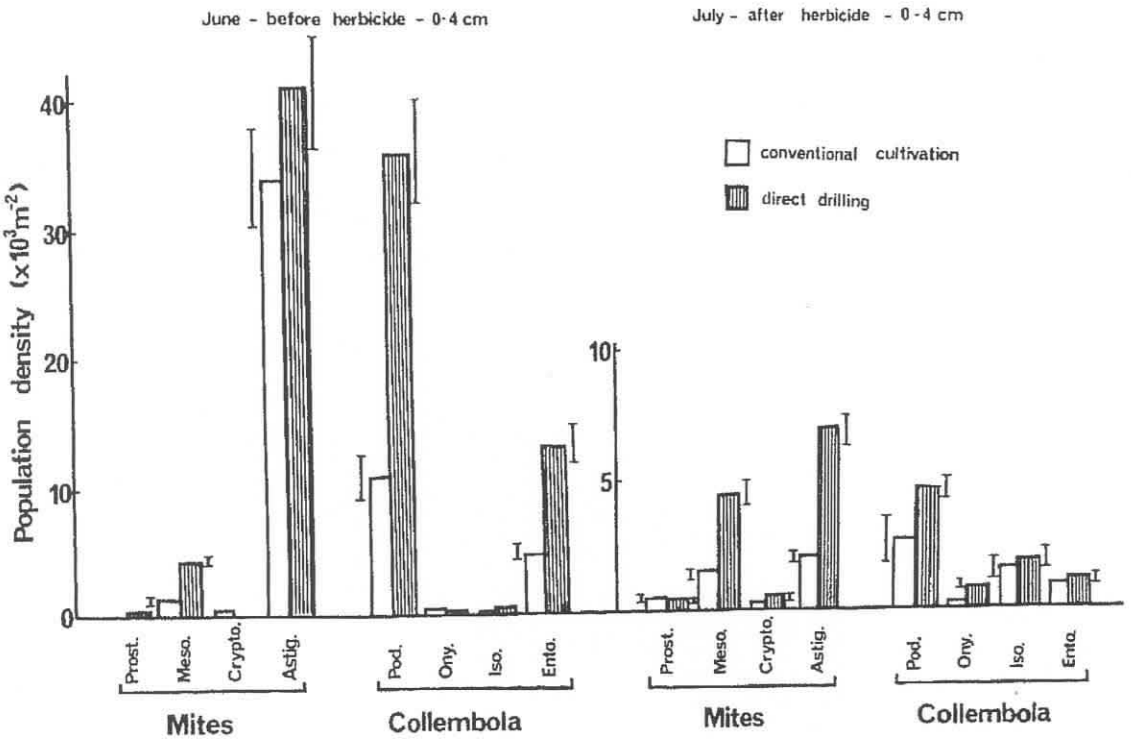

FIGURE 2. Population Densities of Suborders of Mites and Collembolan Families Before and Just After Herbicide Application. SE smaller than 150 not indicated. n = 15.

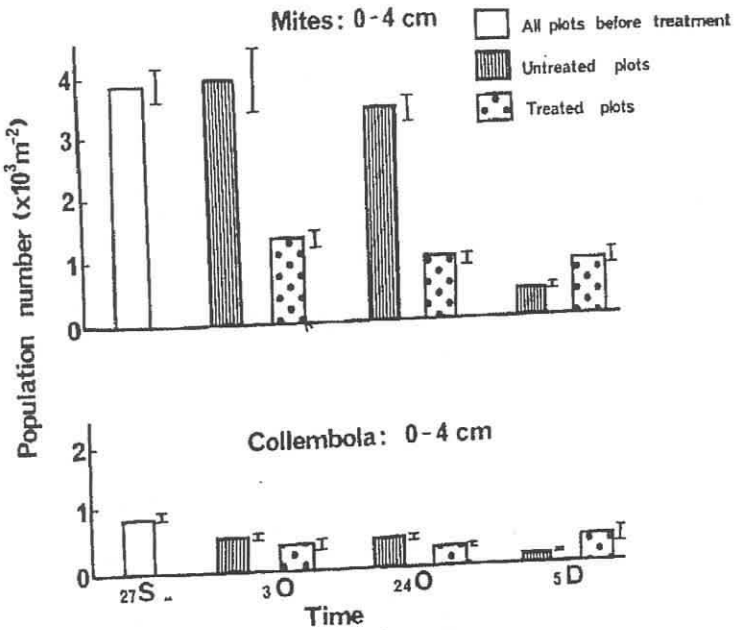

FIGURE 3. The Effect of Herbicide (Hoegrass and Buctril) on Soil Fauna in Red brown earth at the Waite Institute. SE indicated. n = 24.

TABLE 1. Total Animals Extracted from Red brown earth at the Waite Institute (m^{-2}). The figures are means of 24 sample units.

	27/9/80 Pretreat.	3/10/80 Herbicide		24/10/80 Herbicide		5/12/80 Herbicide	
		-	+	-	+	-	+
Mites							
Prostigmata	2625	3025	1125	2520	563	40	0
Mesostigmata	980	1125	105	250	186	145	375
Cryptostigmata	815	225	89	480	167	190	500
Astigmata	270	250	145	65	0	21	0
Collembola							
Poduridae	585	395	230	230	186	63	355
Onychiuridae	0	0	21	89	0	21	0
Isotomidae	290	89	0	89	63	0	0
Entomobridae	21	0	0	0	0	0	0

Population Recovery After Herbicidal Treatments at the Avon Site

One year after herbicide application, the total population of mites and Collembola remained lower than the numbers recorded initially before the herbicide was applied (Table 2). The Poduridae, which was the dominant family of Collembola in June 1980, was virtually absent in June 1981 when the family Isotomidae had become dominant and the Entomobryidae had completely disappeared. The astigmatid mites remained dominant throughout the period of sampling with mesostigmatid mites second in numbers.

TABLE 2. Long Term Effects of Hoegrass and Buctril on Soil Fauna (numbers m^{-2})

	June 1980		June 1981	
	CC	DD	CC	DD
0-4 cm				
Mites	34667	46333	800	3167
Collembola	8767	2500	133	400
4-8 cm				
Mites	21633	10766	300	767
Collembola	7600	8033	100	133

DISCUSSION

Data obtained on soil and air temperature, rainfall and relative humidity during these experiments indicated that the climate at the

sites was favourable for survival and reproduction of soil animals.

With the exception of some information on mites and Collembola (Abbott and Parker 1980) there is little published work on the fauna of cereal crop lands in Australia with which to compare the results presented here. The animal groups recorded here are, however, similar to those of cereal-growing areas in Europe and elsewhere (Eijsackers and Bund 1980).

Some herbicides may have little effect on the soil animals present (Edwards and Stafford 1979; Rapoport and Cangioli 1963; Fox 1964; Von Baudissin 1952; Edwards 1964; Davis 1965; Beiringer 1969; Drift 1963). Other herbicides have been shown to be toxic and reduced the population densities and species diversity of soil animals (Battacharya and Joy 1980; Prasse 1975; Edwards and Lofty 1969; Edwards 1970; Ghabbeaur and Imam 1967; Müller 1971). The results obtained here show that Hoegrass and Buctril applied as a mixture are toxic to the soil fauna. Some herbicides, however, may be toxic only to a limited number of animal species. Prasse (1975) reported that simazine significantly reduced the numbers of a cryptostigmatid mite (Tectocepheus velatus). The same herbicide, used by Edwards (1964), reduced populations of isotomid Collembola and predatory mites by 13-50%. In the present experiments the Hoegrass-Buctril mixture affected all groups of animals examined to some extent. It is, however, impossible to say whether both of the two herbicides Hoegrass and Buctril are toxic or if one is more toxic than the other. An experiment is in progress to test each herbicide separately.

Though application of a greater dosage of simazine (Edwards 1964) reduced the numbers of soil animals more than the normal dose, Bieringer (1969), in a different experiment, found that five months after simazine application the population of animals was greater than before application. This may not be the case with the two herbicides used in this study since after one year the population remained less than half of that initially reported before the herbicides were applied.

Adams and Drew (1965) and Kulash (1947) observed sluggish behaviour in the Collembola Onychiurus quadrocellatus, after application of herbicides. Three hours after application of herbicides, Eijsackers and Drift (1976) found total paralysis in Collembola. These results are consistent with the present data which show a marked reduction in total animal numbers found after application of herbicides. It is, however, unlikely that all the animals in the 0-8 cm layer died in their habitats as a result of the herbicides. It is more likely that many died during extraction when they passed through the soil contaminated with herbicides.

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